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Request for grant of a patent

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1. Your reference	WN/MSR/SID.1	
2. Patent application number *(The Patent Office will fill this part in)*	0404689.2	03 MAR 2004
3. Full name, address and postcode of the or of each applicant *(underline all surnames)*	SIDERIS, Constantinos 17 Arsakeiou Str 2045 Strovolos Nicosia Cyprus	
Patents ADP number *(if you know it)*	7901903001	
If the applicant is a corporate body, give the country/state of its incorporation		
4. Title of the invention	Moulding of Plastics Articles	
5. Name of your agent *(if you have one)*	Wynne-Jones, Laine & James	
"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	22 Rodney Road Cheltenham Gloucestershire GL50 1JJ	
Patents ADP number *(if you know it)*	1792001	

6. Priority: Complete this section if you are declaring priority from one or more earlier patent applications, filed in the last 12 months.	Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*
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7. Divisionals, etc: Complete this section only if this application is a divisional application or resulted from an entitlement dispute *(see note f)*		Number of earlier UK application	Date of filing *(day / month / year)*
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8. Is a Patents Form 7/77 (Statement of inventorship and of right to grant of a patent) required in support of this request? — No

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a) any applicant named in part 3 is not an inventor, or
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9. Accompanying documents: A patent application must include a description of the invention. Not counting duplicates, please enter the number of pages of each item accompanying this form:

Continuation sheets of this form	
Description	42
Claim(s)	7
Abstract	—
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Priority documents	—
Translations of priority documents	—
Statement of inventorship and right to grant of a patent (Patents Form 7/77)	—
Request for a preliminary examination and search (Patents Form 9/77)	Yes
Request for a substantive examination (Patents Form 10/77)	—
Any other documents (please specify)	—

11. I/We request the grant of a patent on the basis of this application.

Signature(s) Wynne-Jones, Laine & James Date 3 March 2004

12. Name, daytime telephone number and e-mail address, if any, of person to contact in the United Kingdom W.J. NEWELL (01242) 515807

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SID.1 BPA

DUPLICATE

MOULDING OF PLASTICS ARTICLES

The present invention relates to a method and apparatus for producing plastics articles such as hollow plastics containers (bottles, jars, cups, pails, etc.) by injection stretch blow moulding or injection blow moulding, and in particular but not exclusively to such methods and apparatus using a composite injection-blow mould set and an injection moulding machine.

BACKGROUND:

Injection and stretch blow moulding machines and mould sets are commercially available for the production of hollow plastic containers. In the 'two-stage process', an injection moulding machine is used to mould preforms which are cooled to ambient temperature and stored for later use. Independently a stretch blow moulding machine uses these preforms, reheats them to a stretch-blow temperature, stretches them and blow moulds them in blow mould sets to the shape of the required container. Machines of many cavities have been developed for high production rates with this 'two-stage process', which are prohibitively expensive for processors requiring lower outputs. Also this 'two-stage process' is not well suited to containers with asymmetrical shapes (e.g. oval) or with wide neck openings (jars).

In the 'one-stage process' the two steps of injection moulding the preforms and stretch-blowing them into containers are achieved within one machine using machine-specific mould sets. The preforms are moulded in an injection mould set, cooled to their average stretch-blow temperature in this mould set and then the mould set opens and the preforms are transferred either

to a conditioning station for further temperature conditioning or directly to a stretch-blow station where they are stretched and blown in blow mould sets into the final container shape. The formed containers are then taken to another station where they are released or ejected. These machines usually employ a vertical injection clamp and rotary mechanisms for transferring the products between stations.

One-stage machines are well suited to low production rates and to containers with asymmetric shapes or with wide neck openings. The one-stage process is less energy intensive than the two-stage process because it eliminates the need for complete cooling of the preforms and their reheating for stretch-blowing.

One-stage machines have several stations (injection, conditioning, stretch-blow, container ejection) and utilise complex and costly mechanisms for transferring the preforms between stations. Also they usually have separate clamping mechanisms for the opening and closing of the injection mould sets (vertical clamp) and of the blow mould sets (horizontal clamp). The mould sets used in one-stage machines are costly because, amongst other reasons, some mould components like neck formers or injection cores must be duplicated several times, as several sets are needed to carry preforms from station to station. Furthermore, these costly mould sets are machine specific and cannot be used on other machines. In view of these factors, one-stage machines require high capital expenditure per unit of production output.

Disadvantages of the one-stage machines include:

- the need for complex preform transfer mechanisms,

- the need for separate clamping mechanisms for injection and blow,
- the duplication of mould components, and
- the relatively low production rates.

Some attempts to use one clamping mechanism for both injection and blow mould sets have been made. In these attempts (e.g. Marcus Paul, US4376090), even though the blow mould set has been incorporated within the same clamping plates as the injection mould, the movement of these clamping plates is used to place the preforms in the blow cavities rather than to open and close the blow mould, because the blow moulds are oriented with their parting plane perpendicular to the clamping plates rather than parallel. This necessitates the use of separate mechanisms to open and close the blow moulds. Additionally some of these attempts (e.g. Pereira, WO 03/068483) have placed between the clamping plates not just the moulds but also complex rotary preform transfer mechanisms and the stretching mechanism. This requires that the clamping unit has a large distance between its plates to accommodate twice the height of the blow-moulded item, and also the complexity of the preform transfer mechanism is no better than that of existing one-stage machines. Furthermore the rotary preform transfer mechanism needs to be supported on the machine frame, with provision for additional lateral movement during the opening and closing of the clamp. This makes it effectively a self-standing mechanism and not really part of the mould, and also makes mould changes time consuming.

The complexity of preform transfer mechanisms and the extent of costly duplication of mould parts is related to the number of process stations or product positions present within the machine or the clamping plates. Conventional

attempts to eliminate some of the disadvantages of the one-stage machines, propose the use of a minimum of three such stations or positions, resulting in either complex transfer mechanisms or duplication of mould parts or both. Additionally such attempts have not succeeded in offering an increase in the output rates of the commercially available one-stage machines.

In this specification the terms 'injection (stretch) blow-moulding' and similar are used to describe a process in which an article is formed by injection-moulding a preform and then blow-moulding said preform with an optional stretching step. The term 'parting line' is used in the usual sense of describing a line along which the closed mould parts meet.

Accordingly, there is a need for an apparatus and method which possess the advantages of the one-stage process in terms of lower energy requirements, and the ability to cope with asymmetric shapes or wide necks, but which does not require costly duplication of equipment and high investment in purpose-built machinery and equipment. There is also a need for a mould set which can be mounted in conventional types of injection-moulding machines and which makes use of the existing platen actuators for opening and closing of both the injection-moulding cavities and the blow-moulding cavities.

It is an aim of this invention to provide a one-stage method and apparatus for injection (stretch) blow moulding of plastics containers, which utilises a single clamping unit (one station) for opening and closing of both injection and blow moulds.

A further aim is to use only one composite injection-blow mould as a single station in the single clamping unit, with only two types of preform location

within it (injection location and stretch-blow location) thus eliminating complex preform transfer mechanisms and also eliminating duplication of mould parts.

It is a further aim of the invention that the said composite injection-blow mould will have a construction such that it can be used on any suitable injection moulding machine with a large enough clamping unit to accommodate it, thus giving additional production flexibility to its user.

A further aim is that the said composite injection-blow mould will have a construction such that it can be quickly and easily placed on and removed from the machine, for minimum production changeover time.

It is a further aim of the invention that the said composite injection-blow mould will have a modular construction such that different containers can be produced on the same composite mould by changing only some mould parts like blow cavities, injection cores, injection cavities or neck formers.

Another aim of the invention is that the method can be implemented either using a standard low cost injection moulding machine or a specifically adapted low cost injection moulding machine.

A further aim of the invention is that the produced containers can be ejected in an ordered way so that if needed a transport system (belt conveyor, air conveyor, etc) can be provided to deliver the containers to storage or further processing, including in-line filling of the containers.

It is a further aim of the invention to provide a process capable of producing containers which do not have a neck support ring just below the neck area.

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Another aim of the invention is that it can be implemented using a fully electric injection moulding machine, in case health and cleanliness criteria require it, for foodstuffs and pharmaceutical applications for example.

An aim of the invention is that the said method and apparatus will require a substantially lower capital investment and provide higher output rates than present one-stage methods, while maintaining the required container quality.

SUMMARY OF THE INVENTION

Accordingly, in one aspect, this invention provides a mould set for use in a method of moulding articles of plastics material, wherein a preform is injection-moulded in an injection moulding cavity and the injection-moulded preform is blow-moulded in a blow-moulding cavity, said mould set comprising an array of injection-moulding cavities and an array of blow-moulding cavities, each of the cavities in each of the arrays having a respective parting line, wherein the parting lines of said injection-moulding cavities and the parting lines of said blow-moulding cavities each define a common mould-separation direction whereby, in use, the mould may be opened in the common mould-separation direction to release the injection-moulded preforms and the blow-moulded products.

In this arrangement, the injection-moulding cavities and the blow-moulding cavities are arranged with their parting lines selected such that there is a common mould-separation direction. In this way, not only may the preforms be formed in the injection-moulding cavities during the same cycle as previous preforms are blow-moulded into the blow-moulding cavities, but also a single movement may be used to open both sets of cavities. In many situations, the

parting line is co-planar, in which case the parting lines of both the injection-moulding cavities and the blow-moulding cavities are parallel and perpendicular to the mould-separation direction.

Although numerous different shapes of blow-moulded articles may be formed using the mould set, in a particularly preferred arrangement, the blow-moulding cavities are generally elongate, with the longitudinal axes of the blow-moulding cavities extending generally perpendicularly to the mould-separation direction. Orienting the longitudinal axes of the blow-moulding cavities perpendicular to the common mould-separation direction may provide a compact arrangement and reduce the distance by which the mould set parts must separate to allow removal of the blow-moulded article.

Numerous different configurations of the blow-moulding cavities and the injection-moulding cavities are possible. In one arrangement, the blow-moulding cavities are disposed in an array to one or both sides or to the top and/or bottom of the mould set, with the necks of the blow-moulding cavities arranged adjacent the periphery of the mould set. This provides the advantage that the necks of the blow-moulding cavities are accessible transversely of the mould set.

The injection-moulding cavities may be disposed in the generally central array in the mould set.

Conveniently, each injection-moulding cavity is aligned with a respective blow-moulding cavity, so that each injection-moulded preform may be moved in a single plane from the injection-moulding cavity to the associated blow-moulding cavity. In other arrangements, the injection-moulding cavities may be offset with respect to their respective blow-moulding cavities.

In one arrangement, the blow-moulding cavities are arranged as a group of a preset number (n) of rows (or columns) of a preset number (m) of cavities on one side of the mould set, and a generally symmetric group of said preset number (n) of rows (or columns) of (m) cavities on an opposite side of the mould set, with the necks of the blow-moulding cavities facing outwardly at the edges of the mould sets, and the injection-moulding cavities are disposed between the two groups of blow-moulding cavities and arranged in a rectangular array of (2 n x m) cavities, with n being an integer greater than or equal to 1. In this arrangement, therefore, each row (or column) of blow-moulding cavities at the edge of the mould set is associated with an aligned row (or column) of injection-moulding cavities towards the centre of the mould set.

Where required, there may be two rows (or columns) of blow-moulding cavities on each side of the moulding set, the rows (or columns) being stacked or spaced in the direction of the common mould-separation direction.

In another arrangement, the blow-moulding cavities may be disposed in two rows (or columns) of cavities at equal spacing, one to either side of the mould set, with the rows (or columns) being offset with respect to each other by one half of the cavity spacing, and the injection-moulding cavities are disposed in a single row (or column) generally centrally between the blow-moulding cavities and each being aligned with a respective blow-moulding cavity.

It is preferred for the mould set to be a composite article comprising two main body portions, and a plurality of modular, removable or replaceable mould set components. The modular mould set components may include one or more of the following: injection cores, injection neck formers, injection cavities, and

blow cavities.

In another aspect, this invention provides an injection moulding apparatus for injection (stretch) blow-moulding of plastics articles, said apparatus comprising:

a mould set comprising an array of injection-moulding cavities and an array of blow-moulding cavities, the cavities in each of the arrays each having a respective parting line, wherein the parting lines of said injection-moulding cavities and the parting lines of said blow-moulding cavities each define a common mould-separation direction whereby, in use, the mould may be opened in said common mould-separation direction to release the injection-moulded preforms and the blow-moulded products;

injection means for injecting plastics material into said injection-moulding cavities to produce said injection-moulded preforms;

mould opening means for opening and closing said mould set in use to allow release of injection-moulded preforms and blow-moulded products;

preform transfer means for transferring injection-moulded preforms from the injection-moulding cavities to the blow-moulding cavities, and

blow-moulding means associated with said blow-moulding cavities and operable for blow-moulding injection-moulded preforms thereinto.

Preferably, the injection-moulding apparatus comprises two facing platen means mounted on a base structure, wherein a first part of said mould set is secured to one of said platen means and a second part of said mould set is secured to the other of said platen means, the apparatus further including platen drive means for effecting relative linear movement of said mould parts between

a closed position and an open position, thereby serving as said mould opening means.

Preferably, the blow-moulding cavities include neck regions disposed adjacent the edge of the mould set and open transversely relative to the axes of said opening and closing movement. The blow-moulding means are preferably disposed generally transversely of said mould set and are operable to apply blow-moulding pressure via said neck region.

Where the apparatus is to be used to form articles by injection stretch blow-moulding, the apparatus preferably includes an elongate stretch means, such as a rod, operable to be introduced in use transversely into the cavity within a preform held in a blow-moulding cavity, thereby to apply a stretching force before or during the blow-moulding.

In particular embodiments, the injection-moulding apparatus may include an array of injection core means, and an array of injection neck-forming means. In one arrangement, the number of injection-mould core means is equal to the number of injection-moulding cavities. In other arrangements, the number of injection-mould core means is equal to an integral multiple of the number of the injection-moulding cavities.

Similarly, the number of injection neck-forming means may be equal to the number of injection-moulding cavities, or it may be an integral multiple thereof.

Where the neck-forming means are equal in number to the injection-moulding cavities, the array of neck-forming means may be operable in use to transfer the injection-moulded preforms from the array of injection-moulding

cavities along at least part of the way to the array of blow-moulding cavities.

The apparatus may include preform transfer means for transferring in use injection-moulded preforms to the blow-moulding cavities from at least part of the way along the path from the injection-moulding cavities. The preform transfer means may comprise any suitable arrangement but typically comprises an array of neck gripping means for engaging in use the neck of a preform. The neck gripping means may grip the neck internally or externally.

Where the injection-moulding apparatus includes elongate stretch means, it preferably includes actuation means for introducing and withdrawing said elongate stretch means to and from the blow-moulding cavities, the actuation means being further operable to apply movement to move said preforms from said injection-moulding cavities to said blow-moulding cavities and/or to transfer said blow-moulded products from said blow-moulding cavities.

In another aspect, this invention provides a method of blow-moulding plastics articles, which comprises the steps of:-

providing a mould set comprising an array of injection-moulding cavities and an array of blow-moulding cavities, each of the cavities in each of the arrays having a respective parting line, wherein the parting lines of said injection-moulding cavities and the parting lines of said blow-moulding cavities each define a common mould-separation direction;

locating a plurality of previously injection-moulded preforms in said blow moulding cavities;

closing said mould set;

forming injection-moulded preforms using said injection-moulding cavities;

stretching and/or blow-moulding said injection-moulded preforms into said blow-moulding cavities;

opening said mould set to release said injection-moulded preforms and said blow-moulded products, and

transferring said injection-moulded preforms to said blow-moulding cavities.

In a preferred aspect, in each period between the mould closing and the mould opening, a plurality of injection-moulded preforms are formed in the injection-moulding cavities and a plurality of previously formed injection-moulded preforms are blow-moulded in said blow-moulding cavities.

The various embodiments of composite injection-blow mould illustrated herein comprise a set of moulds that can be mounted together or separately onto the plates of the clamping unit of an injection moulding machine. This mould set consists of an injection mould with cavities for the moulding of preforms, and blow moulds with cavities for blowing the preforms into containers. The novel way of arranging the blow cavities in relation to the injection cavities and the clamping plates, allows for a maximum number of cavities to be fitted inside the clamping plates thus maximising the production rate, and also allows the use of a standard low-cost injection moulding machine, which could also be a fully electric machine.

In these embodiments the parting lines of the blow-moulds are placed parallel with the injection mould parting line and also parallel to the clamping plates. In this way the opening and closing of the clamping plates achieves opening and closing of both the injection and the blow cavities simultaneously. In

this manner the clamping force of the clamping unit keeps both injection and blow moulds securely closed against the injection pressure and the blowing pressure. This arrangement also means that the centre-line of the containers (or blow cavities) is perpendicular to the centre-line of the preforms (or injection cavities) and parallel with the clamp plates, which allows the overall mould thickness (distance between clamping plates) to be relatively small even for tall containers, so that the mould set can fit on standard injection moulding machines. This orientation of the blow cavities also means that the stretch mechanism can be placed outside the clamp area, leaving the entire clamp area available for cavities.

In a typical composite mould set there may be one, two or four vertical rows of injection cavities for preforms, placed centrally on the clamping plates. With the clamping plates of injection moulding machines being square or nearly square, this vertical arrangement of injection cavities would leave space on either side of the injection mould available for blow cavities. The same number of blow cavities as injection cavities are placed, half on one side and half on the other side of the injection cavities. The blow cavities may be arranged so that the necks of the containers are towards the outside edges of the clamp plates, facing sideways, upwards or downwards, so that the stretch rods – where employed - can enter the cavities from the sides, the top or the bottom of the clamping unit. Typically the blow cavities may be arranged with the container necks facing the sides of the clamp and the container bases facing the centre of the clamp towards the injection cavities. Although not preferred, it is possible to place injection and blow cavities asymmetrically on the clamp plates, for

example the injection cavities on one side (rather than centred) and the blow cavities on the other.

The composite injection-blow mould set could be of a modular design, with interchangeable parts such as e.g. injection cores, injection neck formers, injection cavity plates (or housings), injection cavities or blow cavities, so that several container shapes/sizes could be produced using the same mould set. The arrangement of cavities in the mould set may determine the maximum container neck diameter, body diameter and height, but within these restrictions several container shapes and sizes can be produced. As a result, each mould set would have the flexibility of producing a variety of containers without excessive mould cost. Also just a few standard mould sets, each having a specific configuration of cavity arrangements, could be used to cover most container shapes and sizes.

With the examples of the method of the present invention described below, in a typical production cycle when the clamping unit of the machine opens, there are the ready containers to be removed from the blow moulds and there are also ready preforms, which must be transferred from the injection cavities to the blow cavities ready to be blown into containers in the next cycle. These movements are made while the mould set is in the open position or while opening and closing. Then the clamping unit closes and while the next set of preforms is being injected the containers are blown from the preforms just placed in the blow cavities. The preforms are not cooled completely as in the 2-stage process, but are cooled only to the temperature of stretch/blowing as in the 1-stage process, so that they can be transferred directly to the blow cavities.

During the transfer time from the injection to the blow cavities, it would be possible if needed to further condition the temperature of the preforms.

Several alternative preform transfer and container removal methods are described below, most of which do not require any duplication of mould parts like injection cores or injection formers. Unlike the related art, the composite mould set described below can contain only one neck former and one core for each cavity of production, minimising mould cost and complexity. The duplication of injection mould neck formers may be preferred in the cases when the container to be produced must be without a neck ring (support ring), but even in these cases neck former duplication is not necessary.

I have developed two basic types of preform transfer methods that can be used in the present invention:

1) Methods in which there is only one set of neck formers, which release the preforms and return to their position in the injection mould for the next cycle. In such cases the preforms are held in their stretch-blowing position, not by the injection neck formers, but by other neck holding devices and the neck portion of the blow moulds. (Referred to as Type 1 preform transfer methods).

2) Methods in which the preform is held in the stretch-blowing position (in the blow mould) by the injection neck formers. In such cases the neck formers transport the preform from the injection cavity to the blow cavity without releasing it, so several sets of neck formers are needed. (Referred to as Type 2 preform transfer methods).

Type 1 methods can vary depending on how far the neck formers take the preforms before releasing them in order to return to their position in the injection mould. There are two basic variations of Type 1 preform transfer methods that can be used in the illustrated embodiments:

a) the neck formers transport the preforms part of the way or all the way to their stretch-blowing position, release them and return to the injection mould for the next cycle;

b) the neck formers do not travel away from their injection moulding position but just open to release the preforms onto another device like a robot arm, which will transport them to their stretch-blowing position. While in this device, the preforms could undergo further temperature conditioning if needed.

In the two above variations of Type 1 preform transfer methods, the preforms can be held in the stretch-blowing position by neck holders, which hold the preforms from the inside surface of the neck, in a way similar to that used in the stretch blow moulding machines of the 'two stage process'. Additionally when the blow mould closes, its neck portion can hold the preforms from the outside of the neck, around the support ring or around the neck screw threads of the preforms. In the latter case there is no need for a neck support ring to be incorporated in the preform design because it is held from the neck screw threads.

Also in the two above variations of Type 1 preform transfer mechanisms, the current invention provides for the removal of the ready containers when the mould opens, by moving the neck holders that hold them. The neck holders can move the ready containers out of the mould, release them and then move in

position to take the next set of preforms that have been injection moulded in the previous cycle. Alternatively, to save time, there could be two sets of neck holders, one removing the containers and releasing them or delivering them to a transport system, and one taking the new set of preforms that have been injection moulded in the previous cycle.

Type 2 methods can vary depending on how many sets of neck formers are used. There are two basic variations of Type 2 preform transfer mechanisms that can be used in the illustrated embodiments:

a) with two sets of neck formers that interchange positions between injection and blow cavities each cycle. The set that is in the blow cavities would release the ready containers and then be positioned in the injection mould for the next cycle. The set that is in the injection mould would not release the preforms but instead transport them to the blow cavities and remain there for the next cycle.

b) with three sets of neck formers that interchange positions between injection cavities, blow cavities and container delivery/ejection position.

With all the different methods described for the removal of the ready containers, the possibility exists to simply eject the containers, or to deliver them in an orderly way to a transport system (like a band or air conveyor), or to carry out additional operations on the containers like filling them. These additional operations could be separate from the container production process or they could be incorporated in it. In the former case for example the containers could be released from the neck formers or neck holders onto a transport system that carries them to a filling machine for in-line filling. In the latter case the filling

could be an additional station of the described apparatus, adjoining the injection moulding machine such that the containers are filled before being released and transported away. The containers could still be held by the neck formers or neck holders while being filled. In this case one additional set of neck formers or neck holders may be needed.

In embodiments where the preform is stretched a mechanism may also be provided to move the stretch rods in and out of the blow cavities in order to achieve lateral orientation of the material. Further a mechanism is provided for allowing air to enter the blow cavities, similar to that in existing stretch blowing machines.

There are several movements required for the methods for preform transfer, container removal, container delivery (if needed), stretching (if needed) and blowing. These movements can be achieved in many ways, including any combination of the following (in order of preference):

- by the movement of the machine clamping plates;
- by the movement of the machine ejector;
- by pneumatic or hydraulic actuators;
- by electric or hydraulic motors.

It is preferred when one of the above ways is used to achieve as many of the required movements as possible. For example the movement needed to remove the finished containers and to transfer the preforms to the blow position may be parallel to the stretch rod movement so the same actuator(s) can be used to carry out these movements. The movement mechanisms are preferably

within the mould set or fixed to the mould, but they also can be fixed to the machine or can be free standing.

The composite injection-blow mould set described below can fit in the clamping unit of a standard injection moulding machine, minimising the investment in machinery. Usually the clamping units of such machines are horizontal but standard machines with vertical clamps can also be used. The present invention also extends to a modified injection moulding machine with re-sized clamping unit (with larger clamping plates, accommodating larger mould thicknesses and possibly with adjusted clamping force) and/or a re-sized injection unit, to ensure that the relative sizing of these components of an injection moulding machine are preferentially selected for the present method to maximise output and minimise energy consumption. Depending on the mechanisms for stretching, container removal and preform transfer, it may be beneficial to adjust the programming sequence of the injection-moulding machine in order to better optimise the process. All such modifications and adjustments from the standard injection moulding machines are considered minor and are not expected to have much impact on machine cost. Further, the present invention provides for additional stations to be used for more operations to the ready containers, like filling, capping, handle application, labelling etc.

Whilst the invention has been described above, it extends to any inventive combination of the features set out above or in the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention may be performed in various ways and, by way of example only, specific embodiments thereof will now be described in detail, reference being made to the accompanying drawings, in which:-

Figure 1 illustrates a cavity arrangement of a composite injection-blow mould set in accordance with this invention, with two rows of preform cavities;

Figure 2(a) illustrates a cavity arrangement of a composite injection-blow mould set in accordance with this invention, with one row of preform cavities;

Figure 2(b) illustrates a cavity arrangement of a composite injection-blow mould set in accordance with this invention, with one row of preform cavities, with blow cavities placed vertically or with preform cavities placed horizontally;

Figures 3 (a) and (b) illustrate a cavity arrangement of a composite injection-blow mould set in accordance with this invention, with four rows of preform cavities;

Figures 4 (a) and (b) are a plan view and side view respectively of a composite injection-blow mould set in accordance with this invention, in open position;

Figures 5 (a) to (f) are plan views of a composite injection-blow mould set in accordance with this invention, at various stages during a production cycle;

Figures 6 (a) to (f) are plan views of a composite injection-blow mould set in accordance with this invention, with robot arm preform transfer arrangement, at various stages during a production cycle;

Figures 7 (a) to (f) are plan views of a composite injection-blow mould set in accordance with this invention, with two sets of neck holders, at various stages during a production cycle;

Figures 8 (a) to (d) are plan views of a composite injection-blow mould set in accordance with this invention, with common movements of stretch rods, container removal and preform transfer, and

Figures 9 (a) to (f) are plan views of a composite injection-blow mould set in accordance with this invention, with two sets of neck formers, at various stages during a production cycle.

DESCRIPTION OF PREFERRED EMBODIMENTS:

In the arrangements described below a composite mould set is made up of composite mould halves 10, which are mounted one on each machine clamping plate 12 (or platen) respectively of an injection moulding machine. The clamping plates are connected by four tie bars 14 in conventional manner.

A variety of different cavity arrangements can be used in the composite mould set of the present invention, with preference being given to symmetrical arrangements for even pressure loading of the clamp unit.

One such preferred arrangement is illustrated in Figure 1, in which there are two vertical rows of preform cavities 16 arranged centrally in the machine clamping plate 12. The number of preform cavities per row shown in Figure 1 is just an example. There could be more or fewer cavities per row, depending on the maximum neck diameter and the production output required and the size of the clamping unit of the machine to be used. The centre lines of the preform cavities 16 are perpendicular to the clamping plates 12 as is usual in

conventional preform moulds. Although it can be greater, the total height (H) of each row of preform cavities, which is the height of the injection mould, is preferred not to exceed the vertical clearance between the tie bars 14 of the machine's clamping unit, in order to facilitate changeovers of mould sets and movements for the preform transfer mechanism.

For each preform cavity 16 there is a corresponding blow cavity 18 to which the injection moulded preform will be transferred for stretch-blowing. The blow cavities 18 corresponding to the left row of preform cavities are arranged in a row and placed to the left of this row of preform cavities, with the centre lines (and parting lines) of the blow cavities 18 being parallel with the clamping plates 12. Accordingly the blow cavities 18 corresponding to the right row of preform cavities 16 are arranged in a row and placed to the right of this row of preform cavities. The injection and also the blow cavities in Figure 1 are numbered from 1 to 12 so there is one injection cavity and one blow cavity with the same number. These are corresponding cavities, whereby the preform from an injection cavity marked with a certain number will be transferred to the blow cavity marked with the same number, for stretch-blowing in the next cycle. This is a preferred arrangement of corresponding cavities for ease of preform transfer, but a different corresponding arrangement can be used.

In Figure 1 the necks 20 of the containers are shown near the edge of the mould set, which is near the edge of the clamping plate 12. This neck position allows stretch rods (not shown) to enter the blow cavities from the side, so that the stretching mechanism is outside the clamping plate area, allowing the entire area to be used for cavities. Also this neck position allows a maximum container

height to be produced on the mould set. If the container height was less than the one illustrated in Figure 1, it would be possible to locate the neck position away from the clamping plate's edge and nearer the preform cavities. However, the preferred neck position is the one shown near the edge, so that the same mould set with the same preform transfer movements can be used for containers of various heights just by changing some mould parts and without major change of the preform transfer movements.

Another preferred cavity arrangement is illustrated in Figure 2a, and consists of only one vertical row of preform cavities 16. In this arrangement the number of preform cavities 16 would preferably be even, so that half of them will correspond to blow cavities 18 on one side of the row of preform cavities 16 and the other half will correspond to blow cavities 18 on the other side. In the example of Figure 2(a) with 8 cavities, preforms from cavities 1, 3, 5 and 7 will be transferred to the corresponding blow cavities on one side and preforms from cavities 2, 4, 6 and 8 will be transferred to the corresponding blow cavities on the other side. In this cavity arrangement (one row of preform cavities), typically the distance between preform cavities is half of the distance between blow cavities, so that during preform transfer the distance between preforms need not be changed. This cavity arrangement may be convenient to use when the container body diameter is large in relation to the neck diameter, or when the height of containers is large. Figure 2(a) also illustrates a variant of this arrangement, with the blow cavities 18 arranged at slightly different heights in order to be aligned with their corresponding preform cavities 16 for easier preform transfer.

Two further possible cavity arrangements with one row of preform cavities 16 are illustrated in Figure 2(b). In the first case, the row of preform cavities 16 remains vertical, but the blow cavities 18 are arranged vertically instead of horizontally, so that the stretch rods would have to enter the cavities from above and from below (not from the sides). In the second case, the preform cavities 16 are arranged horizontally instead of vertically and the blow cavities 18 are in a horizontal arrangement. The arrangements illustrated in Figure 2(b) would be useful for relatively low production rates when only a few cavities are needed, and the containers to be produced are tall.

Figures 3(a) and (b) illustrate a third preferred cavity arrangement with four rows of preform cavities 16, and two rows of blow cavities 18 on either side of the preform cavities 16, stacked side by side as illustrated, with all the container necks being on the edge of the mould set facing outside, as in the previous two cavity arrangements. This cavity arrangement is designed for use for small size containers or when higher production rates are required. In this arrangement the parting lines 17 of the preform cavities 16 are parallel with the parting lines 19 of the blow cavities 18, and the mould-separation direction is the same for all the moulds. Here a separate mechanism (not shown) co-ordinates opening of both of the rows of blow cavities 18

Figure 4 illustrates the main components of a composite mould set with the cavity arrangement of Figure 1 (two rows of preform cavities), showing the mould set in a plan view and a side view in the open position. Some mould components are fixed to the stationary plate 31 of the clamping unit while other components are fixed to the moving plate 32 of the clamping unit. Four tie bars

33 usually guide the movement of the moving plate 32 of the clamping unit. The injection mould part of the composite mould set is similar to the injection moulds used in the related art. A hot runner plate 34 distributes the plastic material to the cavities and keeps it molten at a high temperature, ready to be injected in the next cycle. An array of female cavities 35 is provided with channels around them for circulating a fluid to bring the preform temperature to the desired level. A complementary array of male cores 36 that co-operate with the female cavities 35 and can also have fluid circulating through them for temperature control. An array of neck formers 37 are arranged in two vertical rows, each surrounding a male core with each row of neck formers 37 forming a single unit, which is able to move independently in order to deliver the preforms it is holding to a certain position and which also is able to open in order to release the prefoms. Neck formers can also have fluid circulating through them for temperature control.

The movements of the neck formers 37 (both lateral and rotary) are achieved in one embodiment by the opening movement of the clamping unit or of the machine ejector, facilitated by mechanisms and actuators incorporated in the mould set. This arrangement in which the single set of neck formers move away from their positions in the injection mould and then return in time for the next cycle is in marked contrast to the prior art. In the case of the 'two stage' prior art processes, the neck formers do not move away from their positions except for opening to release the preforms. In the case of the 'one stage' prior art processes the neck formers move away and do not return for the next cycle, but are replaced by another set of neck formers.

On either side of the injection mould is a row of blow cavities, consisting of one set of body halves 38 fixed on the side of the fixed plate 31, one set of body halves 39 fixed on the side of the moving plate 32 and one row of base cavities 40. Each of the two rows of base cavities 40 can have fluid circulating through it for cooling and also has the possibility to move away from the blow mould body halves 38 and 39 to release the bottom of the containers for container removal. All the blow mould body halves 38 and 39 are cooled by circulating fluid, either in the body halves themselves or in the blow mould supporting plates 41. The blow mould supporting plates 41 are themselves supported by spacer plates 42, to cover the space between the blow moulds 38/39 and the clamp plates 31/32. This space exists because usually the mould thickness of the injection mould 34-37 is bigger than that of the blow moulds 38/39.

In the example of the composite mould set illustrated in Figure 4 there are two sets of neck holders 43, each set being attached on a neck holder plate 44, which can move to facilitate the container removal and the preform transfer. For each blow cavity there are two neck holders 43, each on opposite sides of the neck holder plate 44 that holds them. When the mould set is in its closed position, the neck holder on the inside of the mould is operable to hold and form a seal with the inside of the neck of the preform to be stretch-blown into the container, while the neck holder on the outside of the mould is operable to form a seal with the mechanism which supplies blowing air. The movements of the neck holder plate 44 (both lateral and rotary) are preferably achieved by the opening and closing movements of the clamping unit and of the machine ejector,

and, if needed, facilitated by mechanisms and actuators incorporated in the mould set.

The composite mould set illustrated in Figure 4 is intended for use in preform transfer methods that have only one set of neck formers 37 (Type 1 preform transfer methods). In the case of Type 2 preform transfer methods where there may be two or more sets of neck formers 37, the neck holders 43 and the neck holder plates 44 in Figure 4 would be replaced by an additional set of neck formers 37.

For illustration purposes, the containers shown in the drawings are bottles, but the present invention can be used for the production of hollow containers in general, including bottles, jars, cups and pails. Also a variety of plastic raw materials can be used, including PET, PEN, Polypropylene, Polystyrene, Polycarbonate, etc.

The operation of one embodiment of the composite mould set used in the one example of the present invention is illustrated in Figure 5, which shows several plan views of the composite mould set at various stages during a production cycle. Similar parts to those in the embodiment of Figure 4 are given similar reference numerals and will not be described again.

Figure 5(a) shows the mould set in closed position. While in this position the following operations take place. The injection unit of the injection moulding machine, injects molten plastic material into the injection cavities 35 of the mould, via the hot runner plate 34. The fluid circulating in the cores 36 and cavities 35 of the injection mould bring these just injected preforms to the desired temperature for stretch-blowing in the next cycle. The stretching and

blowing mechanism 28 shown schematically in dotted lines moves into place, and the stretch rods start stretching the preforms that were injected in the previous cycle and are now in the stretch-blowing position in the blow cavities. While the stretching takes place as well as after its completion, air is blown into the preforms to blow them against the blow mould cavity 38-40 so that they take the correct container shape. The cooling fluid circulating in the blow cavities or the blow cavity support plates 41 cools the containers that have been just blown. The air is then released from the blow cavities and the stretching and blowing mechanism 28 moves out. Thereafter, the container base cavities 40 can move out to release the bottom of the containers so that the containers can move freely out of the blow mould when the mould set opens.

At the end of the 'mould closed' phase of the production cycle (just prior to the point when the mould set starts to open), there are preforms 30 in the injection cavities 35,36 at a suitable temperature ready to be transferred to the blow cavities for stretch-blowing and there are finished containers 26 in the blow cavities 38-40 ready to be removed.

Figure 5(b) shows the mould set in a partially open position during the mould opening phase. During this early part of the mould opening phase the neck formers 37 and the neck holders 43 move away from the fixed clamp plate 31, but do not follow exactly the movement of the moving clamp plate (unlike other mould components like the injection cores 36). The neck formers 37 and the neck holders 43 move parallel to the movement of the moving clamp plate 32, but they are moved only partially out, so that they remain in the open space between the fixed and moving mould set parts. This is needed in order to

facilitate the preform transfer and the container removal movements. At this position the containers are out of the blow mould halves 38-39 and the preforms 30 (still held by the neck formers 37) have cleared both the female cavities 35 and the male cores 36.

Figure 5(c) shows the mould set in a partially open position during (but towards the end of) the mould opening phase. During the movement of the moving clamp plate 32 from the position in Figure 5(b) to that in Figure 5(c) the neck holder plates 44 have rotated and moved further away from the fixed clamp plate 31. This causes the containers 26 to rotate towards the outside of the mould, leaving the area inside the mould free for the preforms 30 to be transferred to their stretch-blow position. At the same time, during the movement of the moving clamp plate 32 from the Figure 5(b) position to the Figure 5(c) position the rows of neck formers 37 have moved further away from the fixed clamp plate 31 while moving also towards the outside of the mould set and rotating, so as to reach a position towards delivering the preforms 30 to the neck holders 43 for stretch-blowing.

Figure 5(d) shows the mould set when it has just reached the fully open position. From the Figure 5(c) position to the Figure 5(d) position, the neck holder plates 44 with the ready containers 26 have continued to move and rotate, so that the containers 26 are outside the mould ready for ejection and the neck holders 43 on the other side of the neck holder plates 44 are facing inside the mould ready to receive the preforms. The combined rotation of the neck holder plates 44 from the start of mould opening until the position of Figure 5(d) is 180 degrees. The rows of neck formers 37 holding the preforms 30 have also

continued to move and rotate, so that they are aligned with the neck holders 43 onto which they will deliver the preforms they are holding. The combined rotation of the neck formers 37 from the start of mould opening until the position of Figure 5(d) is 90 degrees. As many of the movements as possible for preform transfer and container removal are made during the mould opening phase of the production cycle so that the time needed to complete these movements while the mould set is waiting in the open position is minimised.

Figure 5(e) shows the mould set in the fully open position just prior to the start of the mould closing phase. The mould set remains open between the positions of Figures 5(d) and (e). During this time the containers 26 must be ejected and the preforms 30 must be transferred from the neck formers 37 to the corresponding neck holders 43. This can be achieved as follows:

a) The neck formers 37 holding the performs 30, and the empty corresponding neck holders 43 move towards each other (or holders towards formers or formers towards holders) until the preforms 30 engage the neck holders 43 and are securely in position.

b) The neck formers 37 open, thus releasing the performs 30.

c) The neck formers 37 and the neck holders 43 move away from each other, in the reverse movement of a) above, leaving the preforms 30 behind on the neck holders 43.

d) The now empty neck formers 37 close and are ready to move back into their injection moulding position.

After the completion of the above set of movements, the position is as shown in Figure 5(e) and the mould closing phase can start.

Figure 5(f) shows the mould set in a partially closed position during the mould closing phase. This position corresponds with the position of Figure 5(b), but instead of being during mould opening it is during mould closing. During the mould closing phase, the neck formers 37 follow the same movements that they followed during the mould opening phase, but in reverse, including the 90 degrees rotation. During the mould closing phase, the neck holder plates 44 also follow the same movements that they followed during the mould opening phase but in reverse, except the 180 degrees rotation. The mechanism that rotated the neck holder plates 44 through 180 degrees during mould opening is de-activated during mould closing, so that the preform holder plates 44 with the preforms 30 on them are not rotated but only move laterally and end up in the correct position for stretch-blowing when the mould set is closed.

After the position of Figure 5(f), the mould set continues closing until it reaches the position shown in Figure 5(a), with the injection cavities empty and the preforms in the blow moulds ready for stretch-blowing. The next production cycle can then start.

There are several variants of the operation of the preferred embodiment just described which uses just one set of neck formers (the number of neck formers here being equal to the number of injection mould cavities and the number of blow mould cavities). These variants utilise different ways of transferring the preforms from the injection to the stretch-blow positions and of removing the finished containers.

Figure 6 illustrates the operation of a variant in which the way that the neck holders 43 move to remove the finished containers 26 and take hold of the

new preforms 30 is the same as in the operation of the preferred embodiment just described, but the preforms 30 are moved away from the injection mould 35,36 by a robot arm 46. Having a robot arm 46 that takes the preforms from their injection cores and neck formers and delivers them to the neck holders, allows the temperature of the performs 30 to be further conditioned while in the robot arm 46. This conditioning can be achieved, for example, by air of a certain temperature being sucked or blown through the robot arm along the outside surface of the preforms. The use of a robot arm 46 also allows neck grips to be used instead of neck holders. Neck grips hold the preform from the outside of the neck rather than from the inside, so that they can grip the neck firmly around the screw threads, providing another way of eliminating the need for a neck ring (support ring). Neck grips used in cases when a neck ring is present, can have a simpler shape in the neck grip area, without the screw threads.

Figure 6 shows six plan views at various stages during the production cycle. There is no illustration for the mould set in the closed position, but Figure 6(a) shows the mould set in a partially open position during the opening phase, where the preforms 30 remain on the injection cores 36 (unlike the preferred embodiment described earlier – see Figures 5(b) and (c)), waiting for the robot arm 46 to come into position.

Figure 6(b) illustrates the mould set in fully open position, with the robot arm 46 in place ready to accept the performs 30. The robot arm 46 can move into the position shown from above and to save time it can start moving even before the mould set has reached the fully open position. Figure 6(c) shows the mould set in the same position as Figure 6(b), but the preforms 30 are now in

the robot arm 46. In the time interval between Figures 6(b) and (c), the neck formers 37 are moved forward (preferably by the ejector of the machine) pushing the preforms 30 off the cores 36 and into the robot arm 46. Simultaneously the neck formers 37 open to release the preforms 30 and then they close and move back to their original position.

Figure 6(d) illustrates the mould set in a fully open position, with the robot arms having moved to deliver the preforms to the neck holders. Once the preforms 30 are delivered securely on the neck holders (43), the robot arms 46 move away from the neck holders 43 and out of the mould set, so that the closing phase can start. Figure 6(e) shows the mould set partially closed during the closing phase, after the robot arm 46 has moved out.

The alternative of using neck grips 48 instead of neck holders 43 is illustrated in Figure 6(f). The operation sequence is the same, except the method by which the preforms 30 are transferred from the robot arms 46 to the neck holders/grips 48. The grips 48 are designed to open in order to release the necks, in a way similar to the neck formers 37. During the time interval between Figures 6(c) and (d), the neck grips 48 open in order to release the ready containers 26 and also to be ready to receive the new set of performs 30. The position shown in of Figure 6(d) corresponds to the middle illustration of Figure 6(f), when the robot arm 46 has moved the preforms 30 to the neck grips 48. The neck grips will then close to take hold of the preforms and the robot arm will move out.

In another variant of the operation of the preferred embodiment described earlier (with one set of neck formers 37), the way that the preforms 30 are

moved away from the injection mould can be one of the ones already described, but the way that the neck holders 43 move to remove the finished containers 26 and take hold of the new preforms 30 is achieved in a different way. Rather than having one neck holder plate 44 on either side of the mould, with each neck holder plate 44 having two sets of neck holders 43 (one set on each side of the plate), there are two neck holder plates 44a, 44b on either side of the mould, each neck holder plate 44 having one set of neck holders 43. The one neck holder plate 44a removes the finished containers 26, ejects them and takes position ready for the next cycle, while the other neck holder plate 44b, which is waiting from the previous cycle, moves to take the new set of performs 30. In this way the neck holder plate 44a that removes the finished containers 26, has ample time to take the containers 26 and deliver them either to a transport conveyor or to a position for further processing (e.g. filling).

Figure 7 illustrates this variant by showing six plan views at various stages of the production cycle. The preforms 30 in this case are moved to the neck holders 43 by the neck formers 37, but they could be moved by robot arm 46 if preferred. Figure 7(a) illustrates the mould set in the closed position, while Figure 7(b) shows the mould set in a partially open position during the opening phase.

Figure 7(c) illustrates that in this variant the neck holder plate 44a holding the finished containers 26 does not use rotation to remove the containers, but instead only moves laterally. The neck formers 37 in the meantime start to rotate in order to orient the preforms 30 correctly for transfer to the second neck holder plate 44b.

Figure 7(d) shows the mould set having just reached the fully open position, with the finished containers 26 ready for removal and the neck formers 37 having completed their rotation and in alignment with the neck holders 43 on the second neck holder plate 44b, which have moved in position, ready to move in and take the performs 30 from the neck formers 37.

Figure 7(e) illustrates the mould set in fully open position just before starting to close. In the time interval between Figures 7(d) and (e), the following movements take place:

a) The neck formers 37 holding the preforms 30 and the empty second set of neck holders 43 and neck holder plate 44b move towards each other (or holders towards formers or formers towards holders) until the preforms 30 engage the neck holders 43 and are securely in position.

b) The neck formers 37 open, thus releasing the performs 30.

c) The neck formers 37 and the neck holders 43 move away from each other, in the reverse movement of a) above, leaving the preforms 30 behind on the neck holders 43

d) The now empty neck formers 37 close and are ready to move back into their injection moulding position.

e) Simultaneously with movement c) above the neck holders 43 on the neck holder plate 44a holding the finished containers 26 move out, removing the containers 26.

The movements c) and e) above could be parallel and simultaneous, and so, in such cases they may be achieved using the same actuator or actuators.

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Figure 7(f) shows the mould set partially closed during the closing phase. During the time interval between Figures (e) and (f) the neck formers 37 have moved back in position for mould closing, retracing in reverse their movements during mould opening.

Another variant of the embodiment of this invention that has a mould set with one set of neck formers is illustrated in Figure 8. In this variant, there is one common mechanism 50 for moving the stretch rods 51, removing the finished containers 26 and transferring the preforms 30 from the neck formers 37 to the neck holders 43.

Figure 8(a) shows the mould set in the open position, just having finished its opening phase. The following movements are carried out during the opening phase in order to reach the position illustrated in Figure 8(a):

a) The blow mould bottom cavities 40 move away from the fixed clamp plate in a movement parallel to that of the moving clamp plate 32 (instead of staying with the fixed plate 31 and moving away from the blow mould body halves 38,39).

b) The finished containers 26 follow the same movement as the blow mould bottom cavities 40, clearing the blow mould body halves 38,39.

c) The neck holders 43 that hold the finished containers 26 in the blow mould move away from the fixed clamp plate 31 in a movement parallel to that of the moving clamp plate 32, but at the same time moving outwards. This outward movement releases the containers 30 and also enables the neck holders 43 to move further away from the fixed clamp plate 31 in order to align

themselves with the neck formers 37. The arrows in Figure 8(a) illustrate the path followed by the neck holders 43.

d) A set of container retainers 52 follows the movement of the containers 26, supporting them from the neck so that they do not drop when they are released from the neck holders 43.

e) The neck formers 37 move and rotate by 90 degrees, aligning the preforms 30 with the neck holders that will transfer them to stretch blowing.

Figure 8(b) shows the mould set in the open position, with the mechanism 50 having moved inside the open mould set. At this position the neck holders 43 have been pushed into the preform necks and at the same time another set of neck holders 43 that are permanently fixed to the mechanism have been pushed into the necks of the finished containers 26.

Figure 8(c) illustrates the still open mould set just prior to the start of the closing phase. The mechanism 50 has moved out, carrying with it the finished containers 26 outside the mould and returning the neck holders 43 holding the preforms to their original position ready for stretch blowing after the mould set closes. In the time interval between Figures 8(b) and (c), and before the mechanism starts moving out, the neck formers 37 open to release the preforms 30 and also the container retainers 52 retract to free the containers 26 for removal.

Figure 8(d) shows the mould set in a partially closed position during the closing phase. During mould closing the mechanism 50 holding the ready containers 26 rotates through 90 degrees, so that the containers can be

released and also so that the mechanism will not hit the closed mould during stretch blowing when the stretch rods move in to stretch the preforms.

In all the variants described so far the neck holders 43 held the preforms in the stretch blow position and during stretching the preforms 30 were supported on the neck portion of the blow moulds by a neck ring (support ring) incorporated in the preform design. In the cases when the container design does not allow the use of a neck ring (support ring), all the above described variants are still applicable with the following change: the blow moulds incorporate a neck portion with the full neck design (or close to it) including any screw threads, so that when the moulds close around the preforms they will completely enclose the neck with the screw threads, so that in the absence of a neck ring (support ring) the preform will be supported by the screw threads during the stretching.

The operations of all the mould set variants described so far are for composite mould sets with only one set of neck formers. Another preferred embodiment of the present invention is with a composite mould set that has two sets of neck formers, which interchange positions between injection and blow cavities. The use of this preferred embodiment may be convenient when the container design does not allow the existence of a neck ring (support ring).

The operation of this preferred embodiment is illustrated in Figure 9, which shows plan views of a mould set with two sets of neck formers 37a, 37b, at various stages during the production cycle. Figure 9(a) illustrates the mould set in closed position and Figure 9(b) shows the mould set in a partially open position during the opening phase. These Figures show that in this preferred embodiment the neck holder plates 43 are replaced by neck formers 37a.

Figure 9(c) illustrates the mould set in a partially open position during (but towards the end of) the mould opening phase. In the time interval between Figures 9(b) and (c), the neck formers 37a holding the finished containers 26 opened and released the finished containers, while the neck formers 37b holding the preforms 30 started rotating to align the preforms 30 for the next cycle. The released finished containers can either be allowed to drop or be removed by robotic arms. One possibility is for neck holders 43 to move in from outside the mould, enter the necks of the containers 26 and when the neck formers 37a open, move out in the direction shown by the arrows in the containers in Figure 9(c), removing the containers. In such a case the opening distance of the neck formers 37a must be large enough to allow the whole container to pass through.

Figure 9(d) shows the mould set having just reached the fully open position. In the time interval between Figures 9(c) and (d), the neck formers 37a that had earlier released the finished containers have closed, while the neck formers 37b holding the preforms 30 have completed their 90-degree rotation.

Figure 9(e) illustrates the mould set in fully open position just before starting to close. In the time interval between Figures 9(d) and (e), the empty neck formers 37a moved into the injection mould ready for the next injection cycle, while the neck formers 37b holding the preforms moved outwards, ready for the stretch blow position. Figure 9(f) shows the mould set partially closed during the closing phase.

In another preferred embodiment, similar to the one whose operation was just described, the mould set has three sets of neck formers 37a, 37b, 37c instead of two. The three sets of neck formers interchange positions between

the injection mould, the blow moulds and delivering the finished containers either to a transport conveyor or to a position for further processing (e.g. filling).

The described preferred embodiments and their variants present several ways of transferring the preforms from the injection position to the stretch blowing position and removing the finished containers. Combinations of movements from these described possibilities can also be used to achieve the desired results. Furthermore, in all the above possibilities, the finished containers can be simply ejected, or placed on a transport conveyor, or taken for secondary operations.

For all the variants of the mould sets of all the embodiments described, the movements of the neck formers and the neck holders (both lateral and rotary), as well as any other movements needed for preform transfer, container removal and stretching/blowing, can be achieved by any combination of the following: the opening movement of the clamping unit, the movement of the machine ejector, pneumatic and/or hydraulic actuators and electric and/or hydraulic motors. The use of these methods of achieving movements is known to those familiar with the art of mould design or automation. The maximum use of mechanical movements as a result of clamp opening/closing and of machine ejector movement is preferred, as these are standard machine movements and would minimise mould set cost, energy consumption and cycle time.

The variants of the operation of the mould sets described have the necks of the containers on the sides of the clamp area so that the stretch rods would have to enter the blow cavities from the sides, however, the necks of the containers could also be placed on the top and/or bottom of the clamp area (with

the row or rows of preform cavities placed vertically or horizontally) so that the stretch rods would have to enter the blow cavities from the top and from the bottom.

In all cases mechanisms for the stretching and blowing of the preforms in the blow moulds can be provided. Such mechanisms would be similar to the stretching and blowing mechanisms used in the existing art either in the stretch blow moulding machines of the two-stage process or in the stretch-blowing station of the one-stage process. The design of such mechanisms is known to those familiar with the art of stretch blow moulding.

It should be appreciated that although the combined mould set described in this specification may be used in moulding processes which use a blow-moulding step only, it is envisaged that the mould set will be used primarily in stretch blow-moulding processes which use a stretching step in addition to the blow-moulding..

Furthermore, in addition to the mould set and the injection-moulding machine, four main mechanisms are normally required for operation of the above embodiments, namely an article removal mechanism, a preform transfer mechanism, a stretching mechanism, and a blowing mechanism. Such mechanisms are commonly used in the prior art machines, and the selection of suitable mechanisms is well within the competence of one skilled in the art. It is envisaged that these four mechanisms in most instances will be part of, within, or fixed to, the mould set, with the possibility of the stretching and blowing mechanisms being fixed to or supported by the tie bars or the fixed clamp platen of the injection-moulding machine. It will however be appreciated that the

mechanisms may be mounted on the mould set or the injection-moulding machine or any other suitable structure.

Claims

1. A mould set for use in a method of moulding plastics articles wherein a preform is injection-moulded in an injection moulding cavity and the injection-moulded preform is blow-moulded in a blow-moulding cavity, said mould set comprising an array of injection-moulding cavities and an array of blow-moulding cavities, each of the cavities in each of the arrays having a respective parting line, wherein the parting lines of said injection-moulding cavities and the parting lines of said blow-moulding cavities each define a common mould-separation direction whereby, in use, the mould may be opened in the common mould-separation direction to release the injection-moulded preforms and the blow-moulded products.

2. A mould set as claimed in Claim 1, wherein the blow-moulding cavities are generally elongate, with the longitudinal axes of the blow-moulding cavities extending generally perpendicularly to the common mould separation direction.

3. A mould set as claimed in Claim 1 or Claim 2, wherein the blow-moulding cavities are disposed in an array to one or both sides or towards the top and/or bottom of the mould set, with the necks of the blow-moulding cavities arranged adjacent the periphery of the mould set.

4. A mould set as claimed in any of the preceding Claims, wherein the injection-moulding cavities are disposed in a generally central array in the mould set.

5. A mould set as claimed in any of the preceding Claims wherein

each injection-moulding cavity is aligned with a respective blow-moulding cavity.

6. A mould set as claimed in Claim 5, wherein the blow-moulding cavities are arranged as a group of a preset number (n) of rows (or columns) of a preset number (m) of cavities on one side of the mould set and a generally symmetric group of said preset number (n) of rows (or columns) of (m) cavities on an opposite side of the mould set, with the necks of the blow-moulding cavities facing outwardly on the edges of the mould sets, and the injection-mould cavities are disposed between the two groups of blow-moulding cavities, and arranged in a rectangular array of (2n x m) cavities.

7. A mould set as claimed in Claim 6, comprising at least two rows (or columns) of blow-moulding cavities on each side of said moulding set, the rows (or columns) being stacked in the direction of the common mould-separation direction.

8. A mould set as claimed in Claim 5, wherein the blow-moulding cavities are disposed in two rows (or columns) of cavities at equal spacing, one to either side of the mould set, with the rows or columns being offset with respect to each other by one half the cavity spacing, and the injection-moulding cavities are disposed in a single column or row disposed generally centrally between the moulding cavities and each being aligned with a respective blow-moulding cavity.

9. A mould set according to any of the preceding Claims, comprising two main body portions, and a plurality of modular, removable or replaceable mould set components.

10. A mould set according to Claim 9, wherein said modular mould

set components include one or more of the following:

injection cores

injection neck formers

injection cavity plates (housings)

injection cavities, and

blow cavities.

11. An injection moulding apparatus for injection (stretch) blow-moulding of plastics articles, said apparatus comprising:

a mould set comprising an array of injection-moulding cavities and an array of blow-moulding cavities, the cavities in each of the arrays each having a respective parting line, wherein the parting lines of said injection-moulding cavities and the parting lines of said blow-moulding cavities each define a common mould-separation direction whereby, in use, the mould may be opened in said common mould-separation direction to release the injection-moulded preforms and the blow-moulded products;

injection means for injecting plastics material into said injection-moulding cavities to produce said injection-moulded preforms;

mould opening means for opening and closing said mould set in use to allow release of injection-moulded preforms and blow-moulded products;

preform transfer means for transferring injection-moulded preforms from the injection-moulding cavities to the blow-moulding cavities;

blow-moulding means associated with said blow-moulding cavities and operable for blow-moulding injection-moulded preforms thereinto.

12. An injection moulding apparatus according to Claim 11,

including two facing platen means mounted on a base structure, wherein a first part of said mould set is secured to one of said platen means and a second part of said mould set is secured to the other of said platen means, the apparatus further including platen drive means for effecting relative linear movement of said mould parts between a closed position and an open position, to serve as said mould opening means.

13. An injection-moulding apparatus according to Claim 11 or Claim 12, wherein the blow-moulding cavities include neck regions disposed adjacent the edge of the mould set and open transversely relative to the axis of said opening and closing movement.

14. An injection-moulding apparatus according to Claim 13, wherein said blow-moulding means are disposed generally transversely of said mould set and are operable to apply blow-moulding pressure via said neck region.

15. An injection moulding apparatus according to Claim 14, including an elongate stretch means operable to be introduced in use transversely into the cavity within a preform held in a blow-moulding cavity, thereby to apply a stretching force before or during the blow-moulding.

16. An injection-moulding apparatus according to any of Claims 11 to 15, including an array of injection core means and an array of injection neck forming means, for co-operating with said array of injection-moulding cavities.

17. An injection-moulding apparatus according to Claim 16, wherein the number of injection-mould core means is equal to the number of

injection-moulding cavities.

18. An injection-moulding apparatus according to Claim 16, wherein the number of injection-mould core means is an integral multiple of the number of injection-moulding cavities.

19. An injection-moulding apparatus according to Claim 16, wherein the number of injection neck forming means is equal to the number of injection-moulding cavities.

20. An injection-moulding apparatus according to Claim 16, wherein the number of injection-neck forming means is an integral multiple of the number of injection-moulding cavities.

21. An injection-moulding apparatus according to Claim 19, wherein the array of neck-forming means is operable in use to transfer the injection-moulded preforms from the array of injection-moulding cavities along at least part of the way to the array of blow-moulding cavities.

22. An injection-moulding apparatus according to any of the Claims 19 to 21, including perform transfer means for transferring in use injection-moulded preforms to the blow-moulding cavities from at least part of the way along the path from the injection-moulding cavities.

23. An injection-moulding apparatus according to Claim 22, wherein said preform transfer means comprises an array of neck gripping means for engaging in use the neck of a preform.

24. An injection moulding apparatus according to Claim 15 or any Claim dependent thereon, which comprises actuation means for introducing and withdrawing said elongate stretch means to and from the blow-moulding

cavities, said actuation means being further operable to apply movement to move said preforms from said injection-moulding cavities to said blow-moulding cavities and/or to transfer said blow-moulded products from said blow-moulding cavities.

25. A method of blow-moulding plastics articles, which comprises the steps of:-

providing a mould set comprising an array of injection-moulding cavities and an array of blow-moulding cavities, each of the cavities in each of the arrays having a respective parting line, wherein the parting lines of said injection-moulding cavities and the parting lines of said blow-moulding cavities each have a common mould-separation direction;

locating a plurality of previously injection-moulded preforms in said blow-moulding cavities;

closing said mould set;

forming injection-moulded preforms using said injection-moulding cavities;

stretching and/or blow-moulding said injection-moulded preforms into said blow-moulding cavities;

opening said mould set to release said injection-moulded preforms and said blow-moulded products, and

transferring said injection-moulded preforms to said blow-moulding cavities.

26. A method according to Claim 25, operated cyclically, wherein in each period between the mould closing and the mould opening, a plurality of injection-mould preforms are formed in the injection-moulding cavities

and a plurality of previously formed injection moulded performs are blow-moulded in said blow-moulding cavities.

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Figure 1: Composite mould set cavities configuration, with two rows of preform cavities.

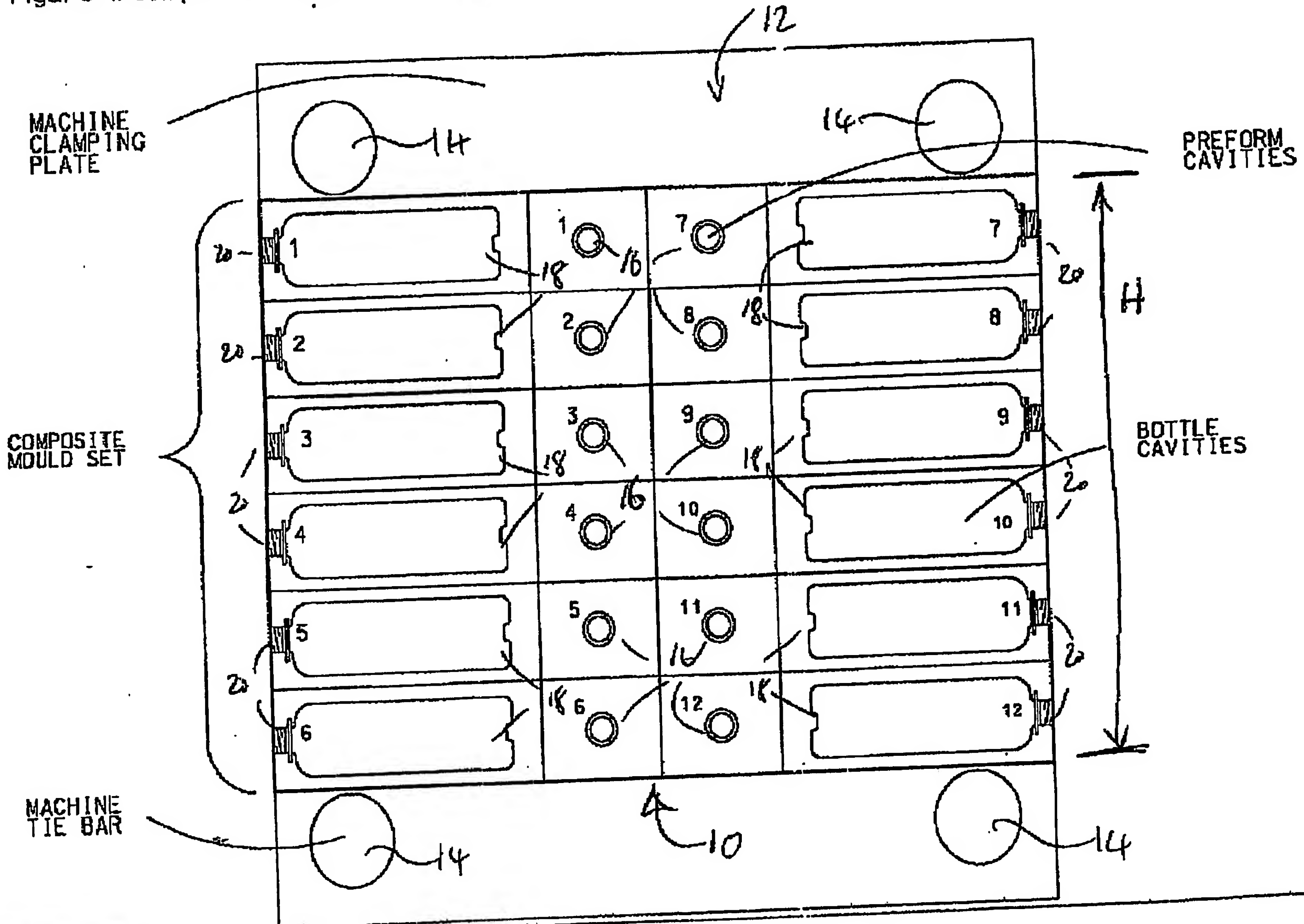

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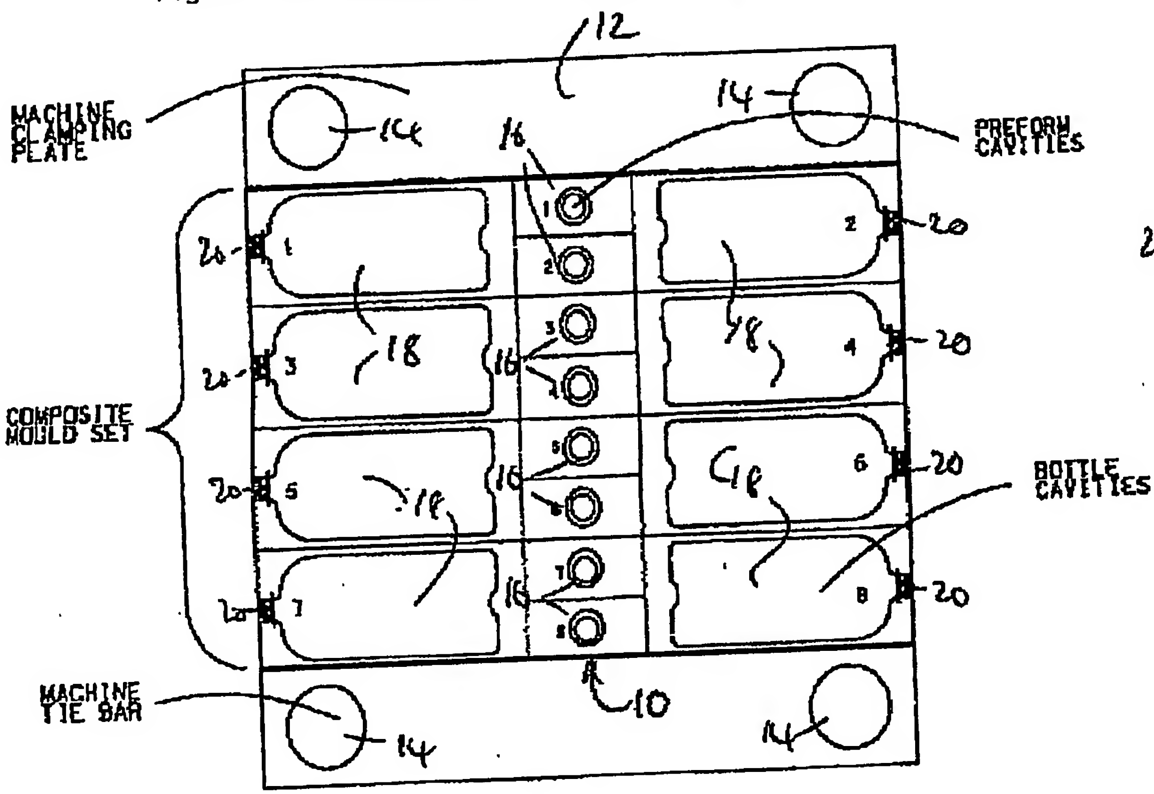
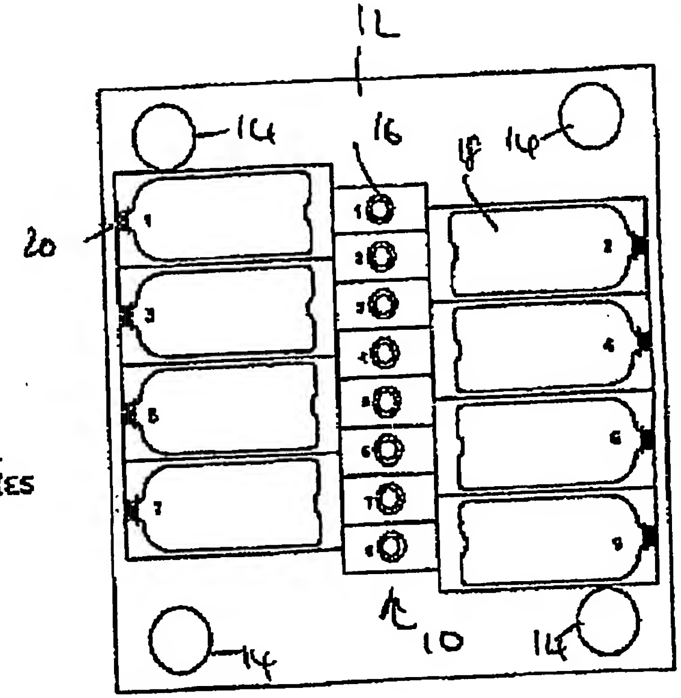
Figure 2a: Composite mould set cavities configuration, with one row of preform cavities.





Alternative configuration

Figure 2b: Composite mould set cavities configuration with one row of preform cavities, with vertically placed blow cavities or with a horizontal row of preform cavities.

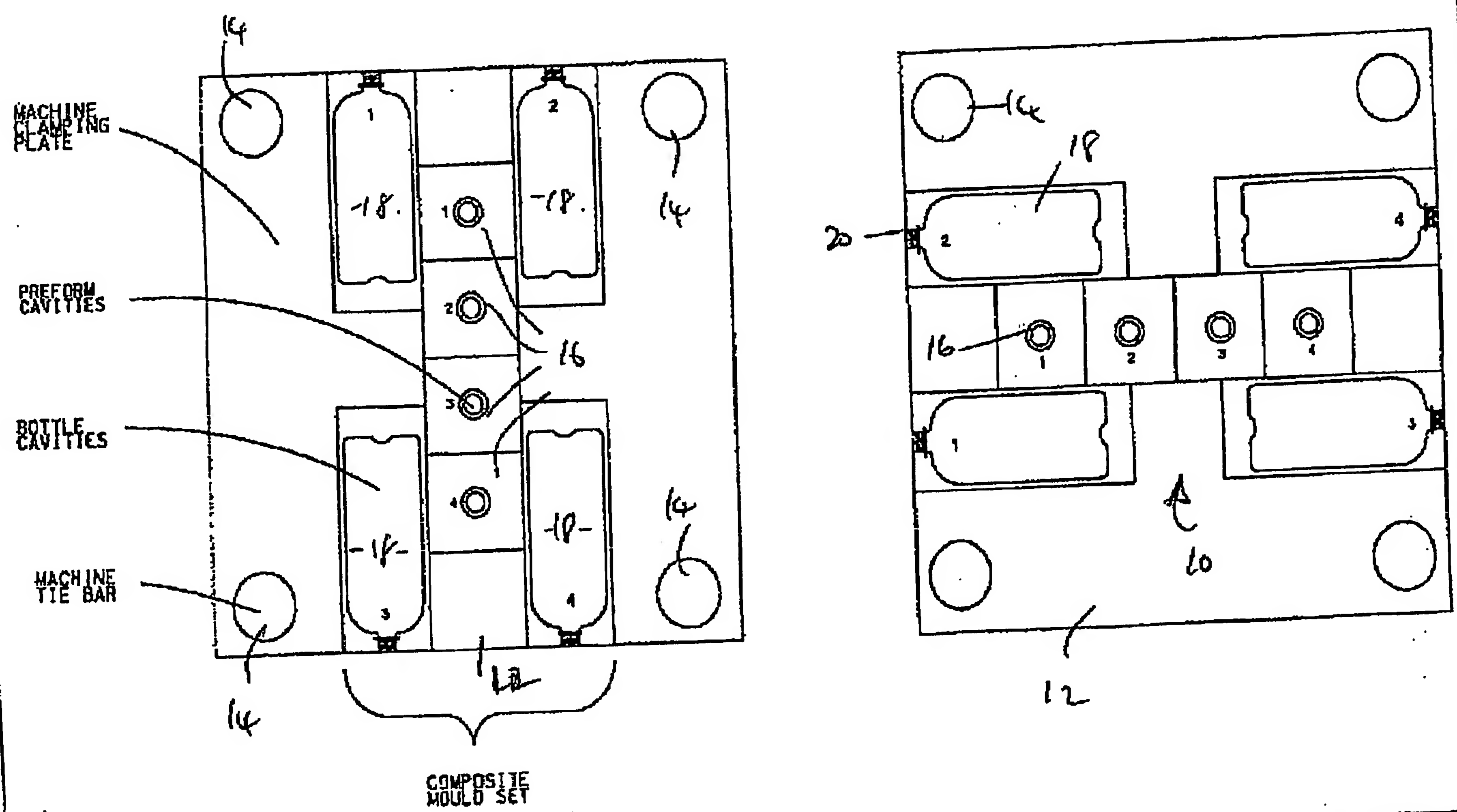


Figure 3: Composite mould set cavities configuration, with four rows of preform cavities,

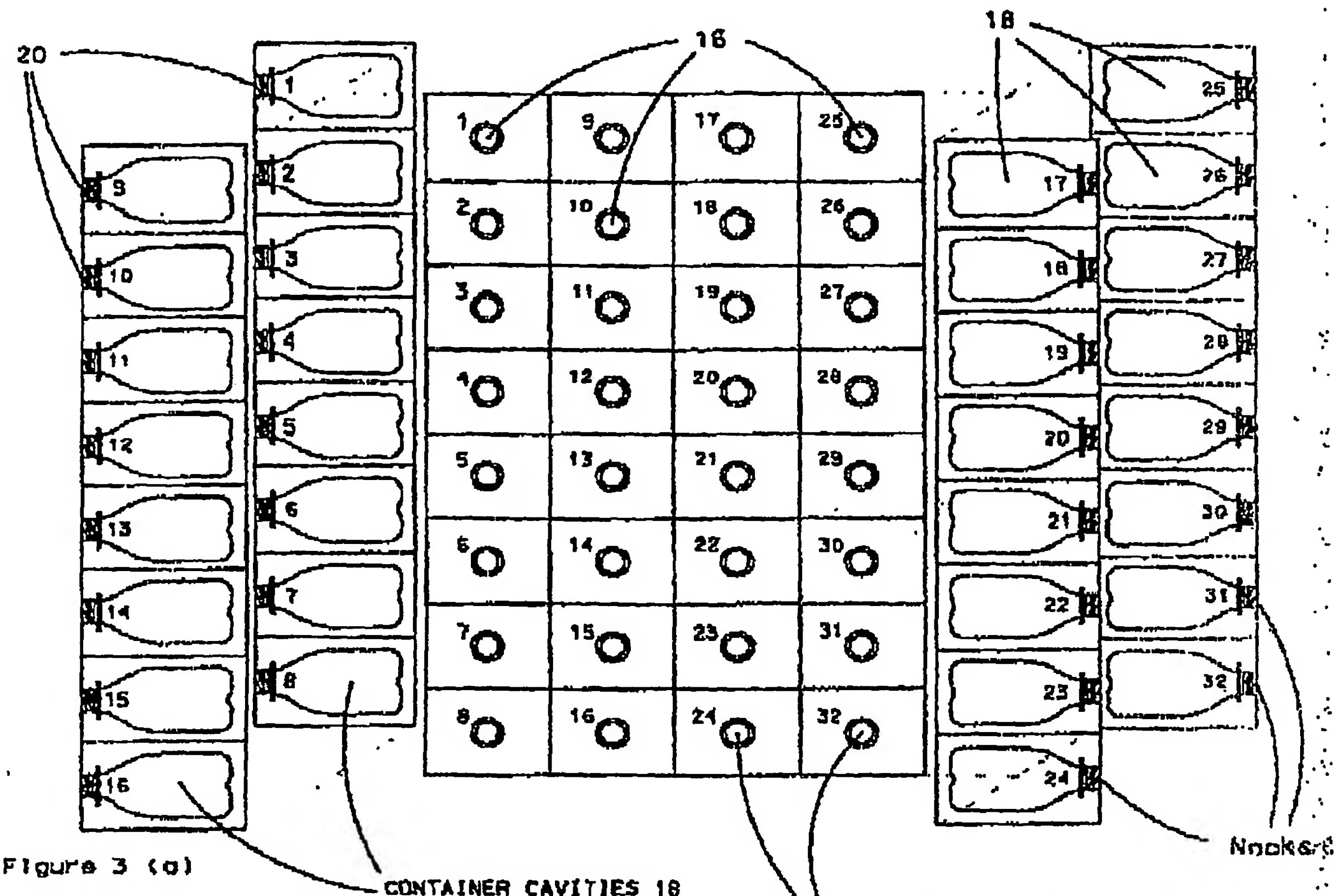


Figure 3 (a)

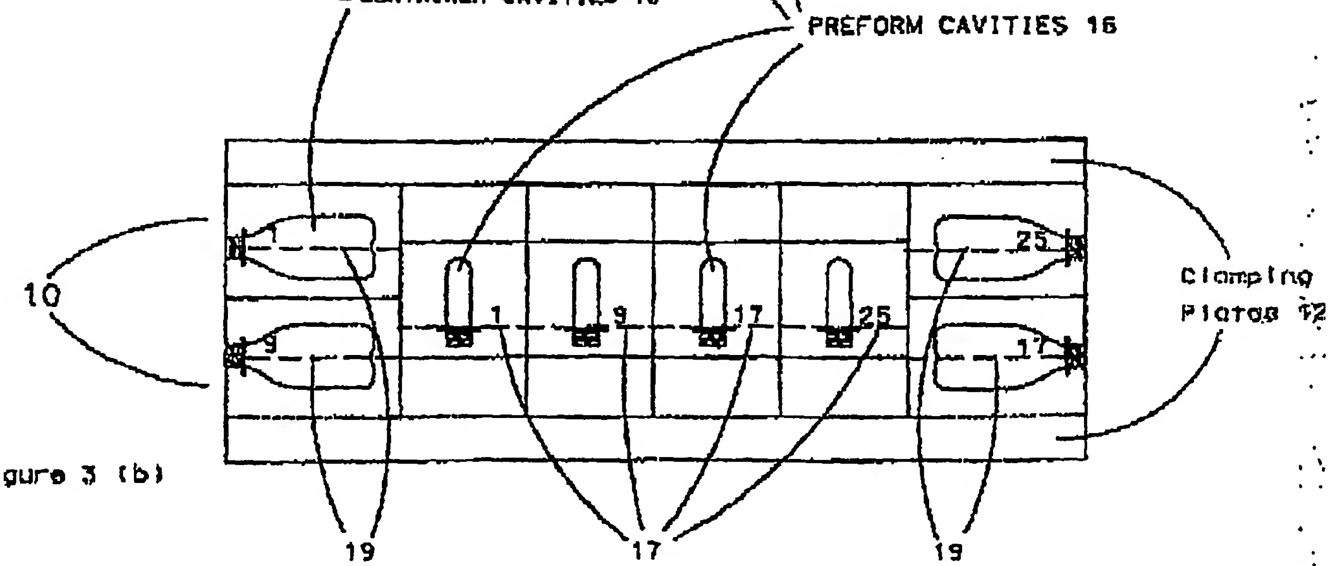


Figure 3 (b)

Figure 4: Main components of composite mould set, in open position.

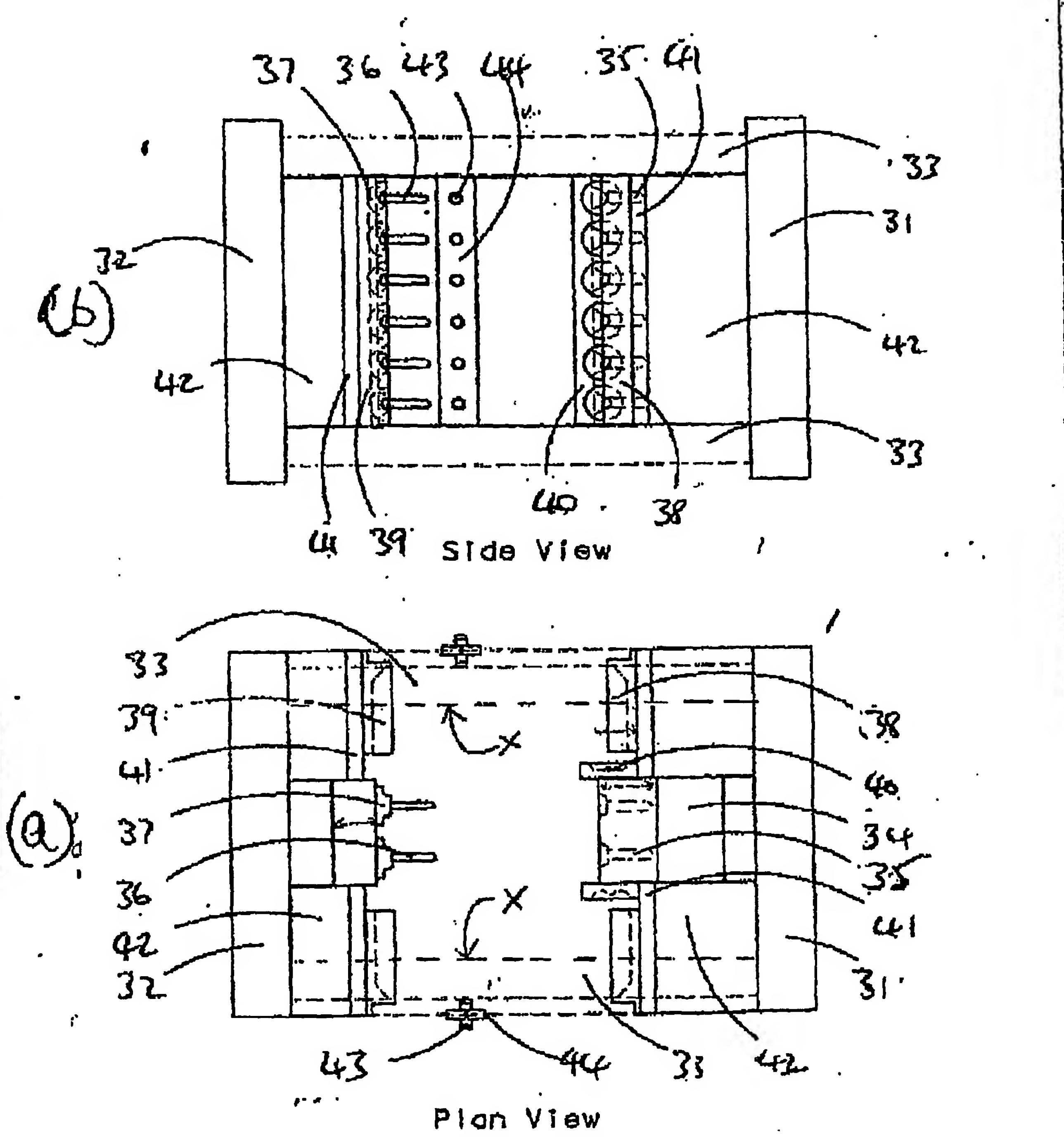


Figure 5: Plan views of a composite mould set at various stages during a production cycle.

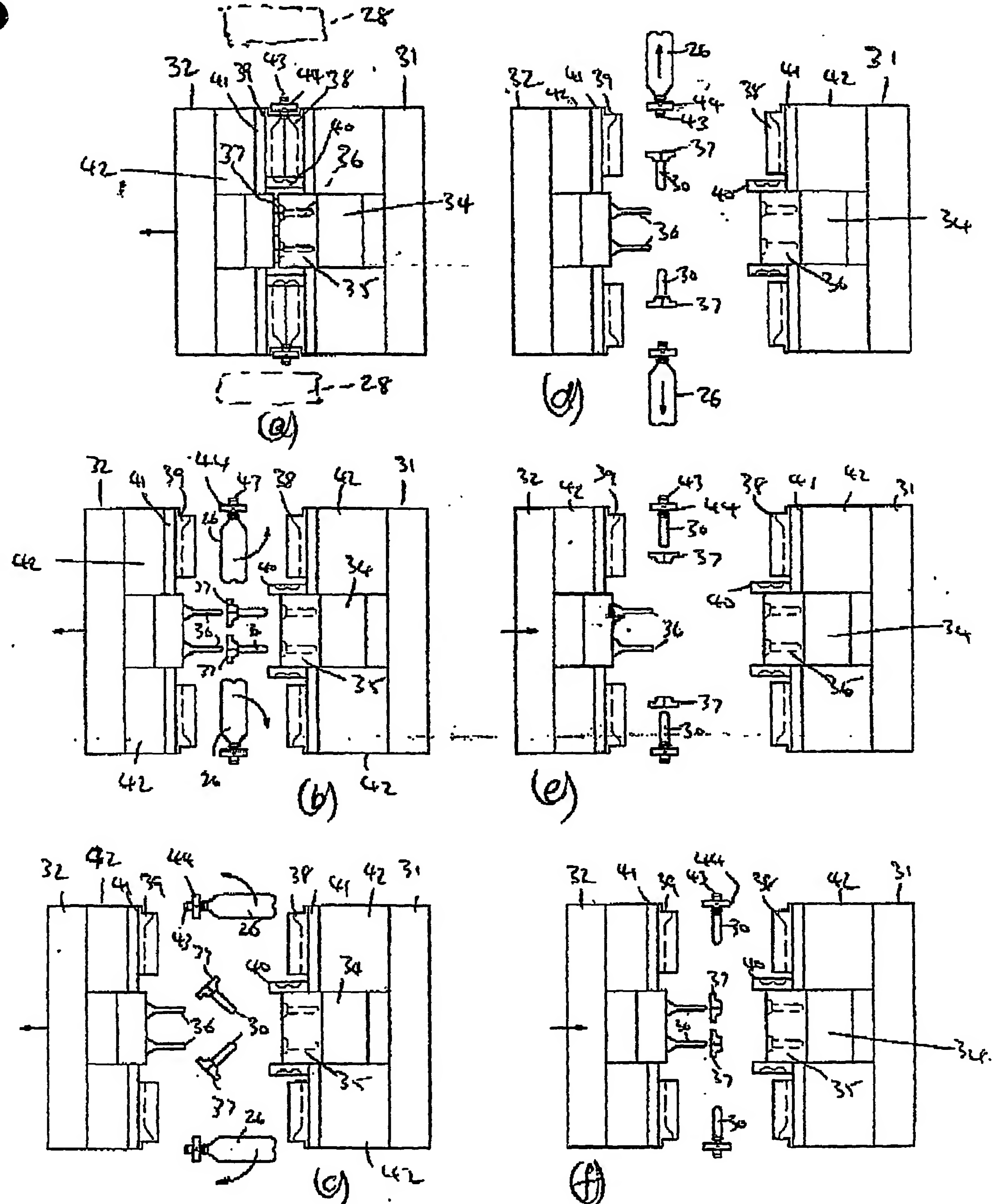


Figure 6: Plan views of a composite mould set at various stages during a production cycle, with robot arm preform transfer.

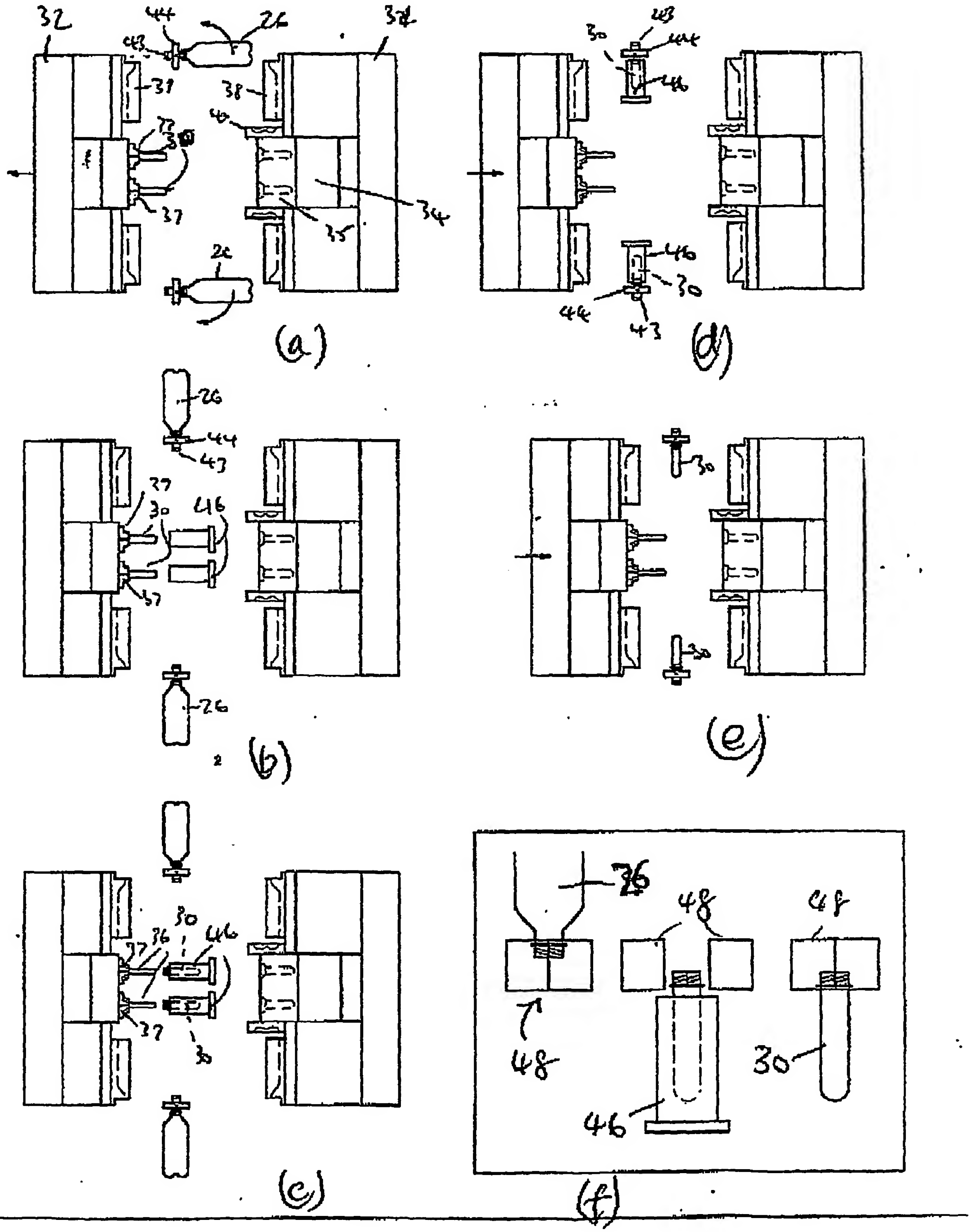


Figure 7: Plan views of a composite mould set at various stages during a production cycle with two sets of neck holders.

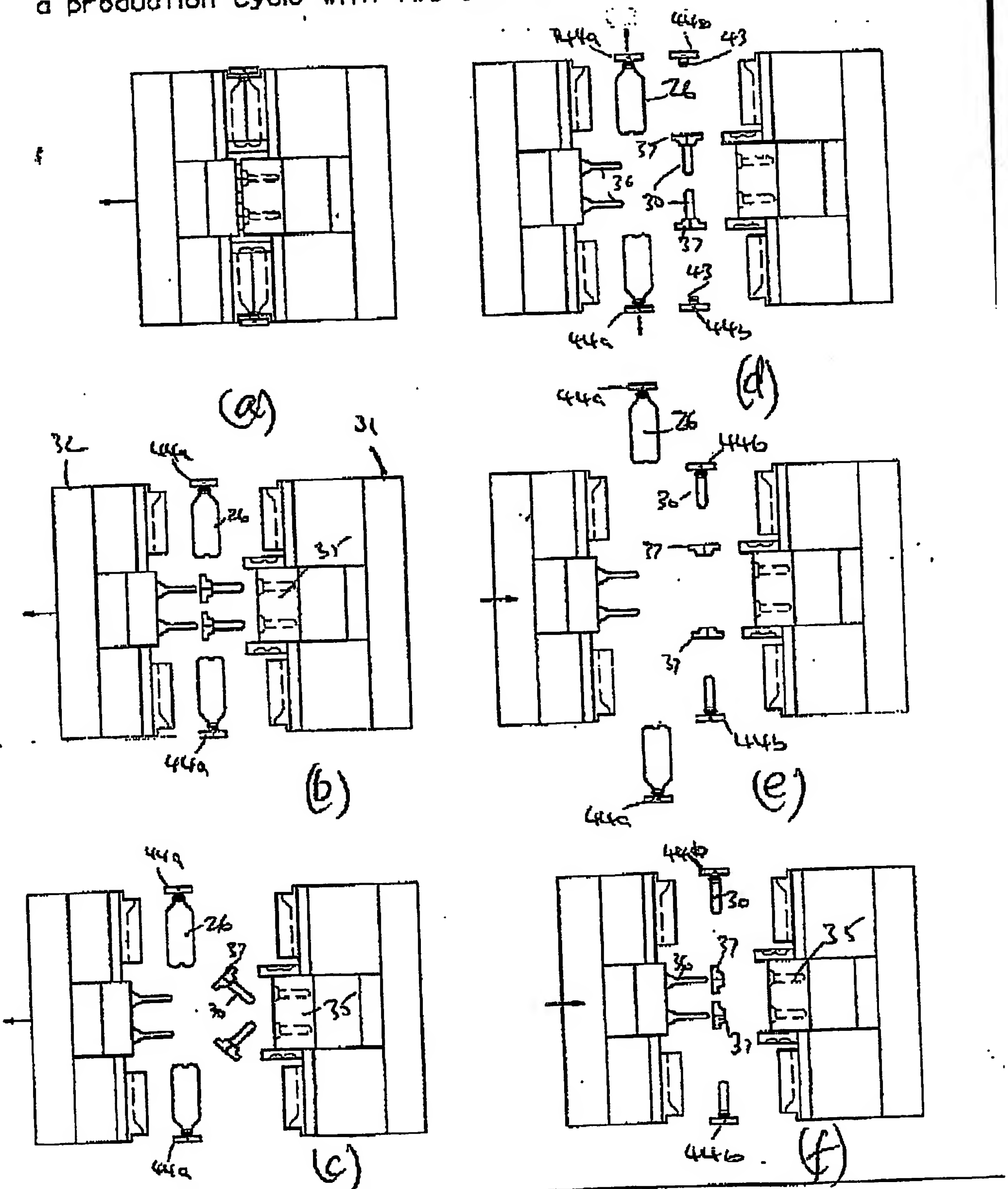
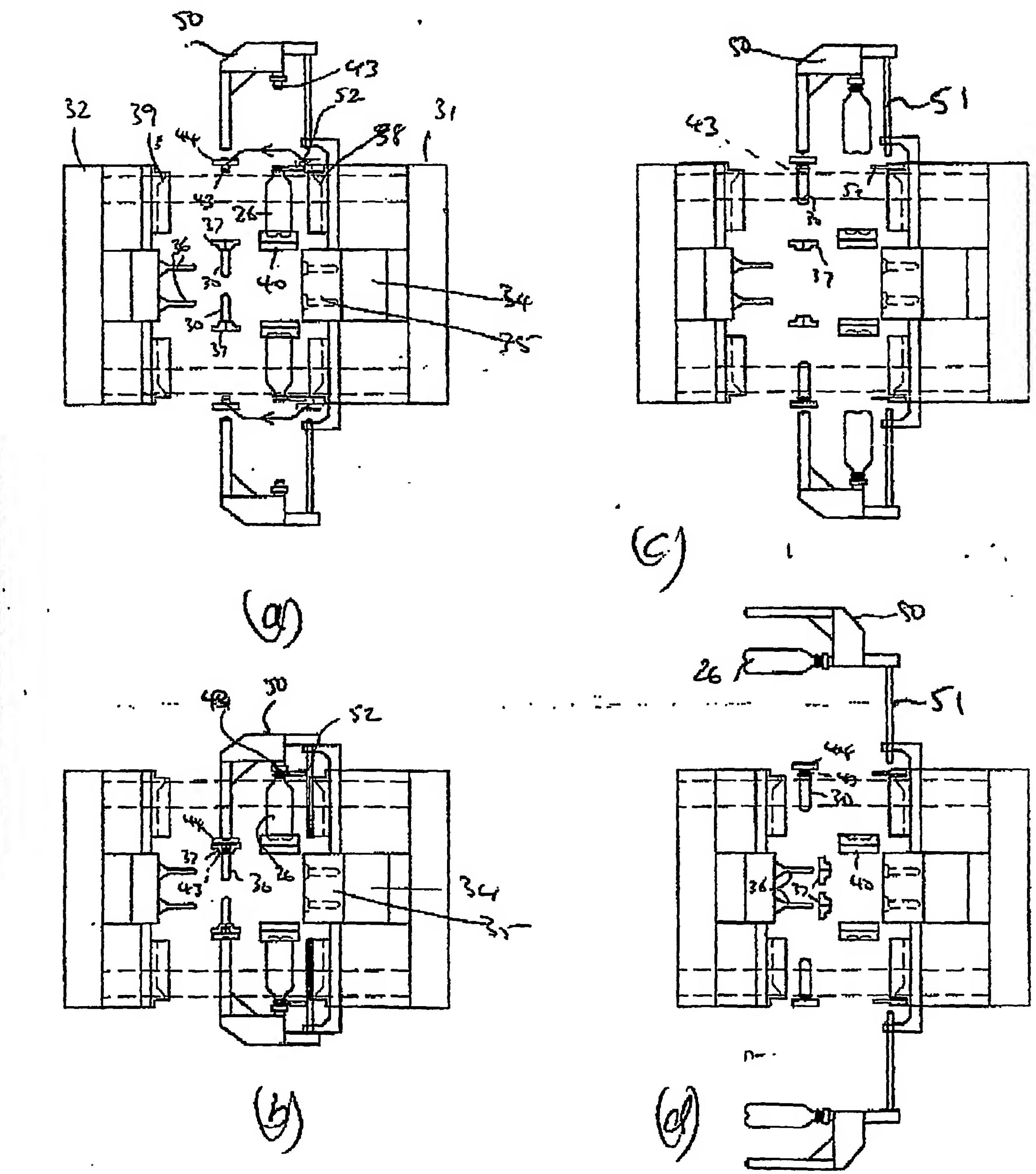
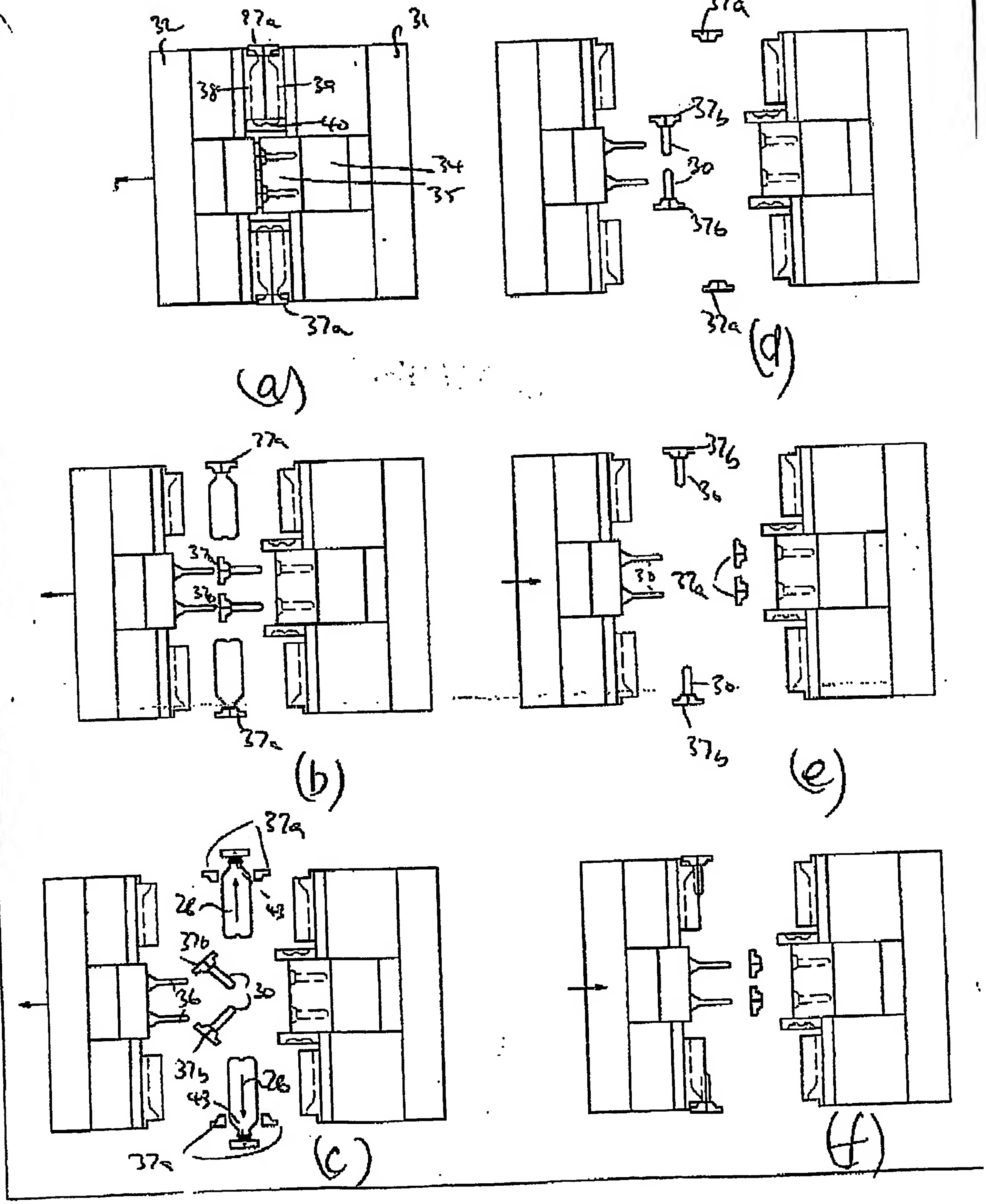


Figure 8: Plan views of a composite mould set at various stages of the production cyc with a single movement for preform transfer, container removal and stretching.



a production cycle, with two sets of neck holders.



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